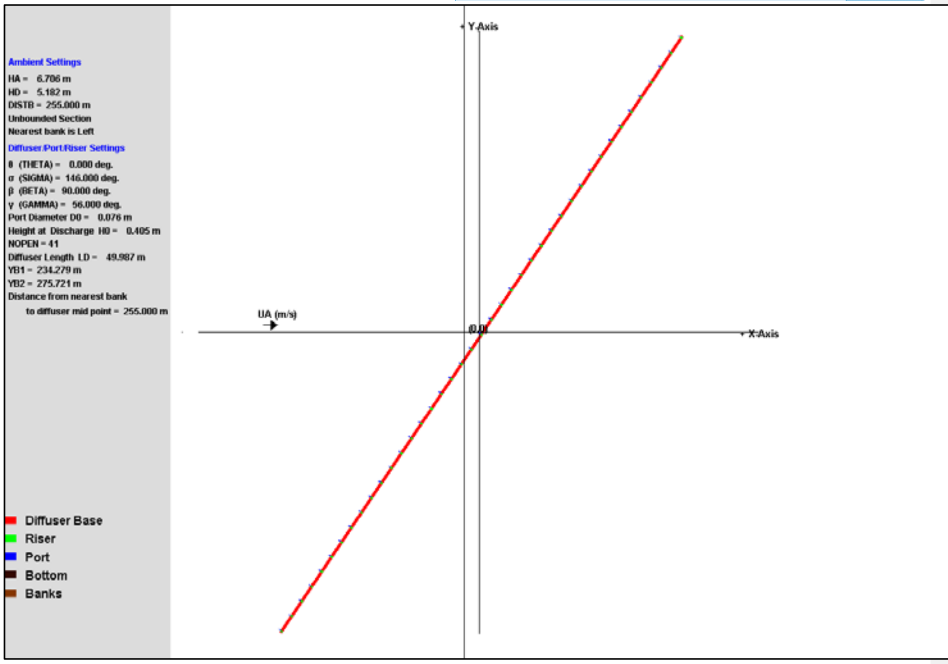
Summary of Findings: ~~CORMIX~~Cormix Modeling of City of Sandpoint Discharge

Prepared by Brian Nickel, EPA Region 10

1 ~~Overview~~Model Inputs

- The river at the Sandpoint WWTP is very wide (9600ft), so the model was run as an unbounded channel.
- The velocity used in the model was 0.2 ft/s, which was the low end of the ambient velocity measured by Bob Steed on 8/3/15. The direction at the surface was north 18° east (18° "clockwise" from true north). The direction at 80% depth was undetermined, so the direction measured at the surface was used for modeling. Under these conditions, the ambient velocity would push the plume toward the shore and then toward the spit at the north end of the "long bridge."
- Using the map of the outfall provided with the application, I estimate the angle of the diffuser axis relative to the measured current (Cormix calls this angle GAMMA) at 56°, and the angle of the ports relative to the current (SIGMA) at 146°. Since the angle of the ports relative to the current is greater than 90°, the ambient velocity opposes the momentum of the discharge. Cormix will run with this geometry *only if* the "Override Warnings" option is selected from the "Pre-Processing Tools" menu. This diffuser configuration is shown in Figure 1, below. Note that the ambient velocity (UA) is parallel to the x-axis.
- Temperature data collected by DEQ in 2005 indicate a maximum of 0.8 °C of overall temperature stratification from the surface of the river to the bottom, with a median of zero. Both stratified and uniform ambient temperature scenarios were run, using actual temperature data for a particular date and time.

Figure 1: CorSpy view of diffuser from top down (I'm not sure what this graph is telling me)



2 Mixing Zone Sizing

- Dilution factors ~~have been calculated~~were determined for the acute and chronic mixing zones. Dilution factors are the ratios of ambient water to effluent at the edges of the mixing zones. The reciprocals of the dilution factor are the fractions of effluent in the water at the edges of the mixing zones.
- The acute mixing zone was sized based on limiting the zone to 15 minutes (900 seconds) of plume travel. This is one of the methods recommended by the *Technical Support Document for Water Quality-based Toxics Control* (Sections 2.2.2 and 4.3.3) to ensure that an acute mixing zone does not cause lethality to drifting or swimming organisms.
- The chronic mixing zone was sized so that chronic water quality criteria were met at the point where the plume reaches the shore, which about 200 meters from the point of discharge, in the direction of the ambient velocity.
- ~~This is the volume of water that must mix with the effluent before it meets either the acute or chronic criteria. In this case these factors are acute 48:1 and chronic 77:1.~~ The "size" of the mixing zone ~~se dilutions are~~can also be ~~used in combination with the~~expressed in terms of the effluent mixing with a certain fraction of the critical flows ~~to determine the final mixing zone size~~. Critical flows vary by pollutant and the type of criterion (acute or chronic aquatic life, or human health). For most ~~, for example,~~ chronic aquatic life criteria, the 7Q10 flow is used.

Commented [NB1]: It's not really a "graph." This is a top-down ("plan") picture of the diffuser. It shows the placement of the diffuser relative to the ambient velocity. The ambient velocity is notated as "UA," and it is parallel to the x-axis. It also shows the axis of the diffuser (red), and the ports (blue). Because the ports are small relative to the size of the diffuser, they're a little hard to see, but if you zoom in, you can see them pointing up and to the left, which means they oppose the ambient velocity "UA," which points to the right.

It also shows "risers," in green. Sandpoint's diffuser doesn't actually have "risers," rather, the ports are just holes in a large pipe. The "risers" are just CORMIX's way of showing the height of the ports off the bottom of the river.

Commented [NB2]: Idaho DEQ's draft mixing zone guidance references the TSD's recommendations, but I don't know if you want to refer to the DEQ guidance since it is not yet final, so, for now, I'll just reference the TSD.

Commented [NB3]: The nearest diffuser port is actually 231 meters from shore. Also see my comment in the "parameter specific results" section, below.

Commented [JuneB4]: Brian, as you can tell I am not sure how you go from dilution factor to get MZ when MZ size is needed to calculate the DF. Did you assume some MZ size to calculate your DFs?

Commented [NB5R4]: I'm hoping my re-write helps, but here's some more explanation.

One can calculate a dilution factor that results from a mixing zone of, say, 25% of the critical low flows of a stream. And/or, you can run a plume model to determine what the dilution factor is at certain important locations (like the river bank, in this case, or a drinking water intake), or at certain travel times or distances from the outfall.

When I ran Cormix, I didn't start with an assumed mixing zone size. Rather, I evaluated the Cormix results to determine the dilution factors.

For the acute mixing zone, I looked to see how much dilution was achieved after 15 minutes (900 seconds) of plume travel. That was how I sized the acute mixing zone, or equivalently, how I determined the acute dilution factor.

Since the shore is about 200 meters "downstream" of the discharge, I also looked at the dilution factor at that point. I thought DEQ would consider that to be the extent of the chronic mixing zone. As you can see from other comments in this document, we need to make sure that's what you want to authorize for the chronic mixing zone.

Having obtained dilution factors from the model, I could then back-calculate the "sizes" of the mixing zones in terms of percentages of critical flows.

Ammonia is an exception because the averaging period for the chronic ammonia criterion is 30 days, thus, the 30B3 is used. For acute aquatic life criteria, ~~ammonia uses~~ the 1Q10 flow is used.~~; mercury and chlorine use the 7Q10 flow~~.

~~The dilution isolines shown in Figures 2 and 3 outline the modeled size and shape of the effluent plume during two conditions: (1) when the temperature of the river water at the diffuser is uniform in temperature from top to bottom; and (2) there is a difference of 0.8°C temperature from top to bottom. The difference in water density created by second scenario shows a significant positive effect on mixing; however, river temperature profile data show that a uniform temperature from top to bottom is typical during summer months.~~

- ~~Results shown in Figure 2 indicate that the cold water aquatic life chronic ammonia plume extends 440 meters before it meets criteria yet the shoreline is only 281 meters from the end of the diffuser. The exact plume shape once it hits the shoreline cannot be predicted without more information. Ammonia has no human health criteria.~~

3 Results

- The dilution isolines shown in Figures 2 and 3 outline the modeled size and shape of the acute and chronic mixing zones (i.e., the portions of the effleunt plume that exceed acute and chronic criteria) during two conditions: In Figure 2, when the temperature of the river water at the diffuser is uniform in temperature from top to bottom; and, in Figure 3, there is a difference of 0.8°C temperature from top to bottom. The difference in water density created by second scenario shows a significant positive effect on mixing; however, river temperature profile data show that a uniform temperature from top to bottom is typical during summer months.

~~1.1~~3.1 Uniform Ambient Density

- Chronic mixing zone: Dilution at 200m downstream (shore): 77:1
  - This is equivalent to the effluent mixing with 15% of the 7Q10 river flow rate of 3,880 CFS or 7.3% of the 30B3 river flow rate of 8,090 CFS.
- Acute mixing zone: Dilution after 900 seconds (15 minutes) of plume travel[1]: 48:1
  - This is equivalent to the effluent mixing with 15% of the 1Q10 river flow rate of 2,410 CFS.

- ~~Note that the chronic dilution factor of 77:1 is equivalent to a 7.3% MZ for ammonia using the 1Q10 critical flow; a 15% MZ for mercury using the 7Q10 critical flow; and a 15% MZ for chlorine using the 7Q10 flow.~~

~~1.1.1~~3.1.1 Parameter-Specific Results

The model predicts poorer mixing with uniform ambient density than with stratified ambient density (see section 3~~2~~.2, below). Thus, the uniform ambient density model was used for further investigation of the mixing zones for specific parameters, using the maximum projected effluent concentration, which is generally the maximum measured concentration multiplied by the reasonable potential multiplier. The results are as follows:

- "Downstream" distance[2] to meet ammonia criteria:
  - Acute: 6.7m
  - Chronic: 440m
- "Downstream" distance to meet chlorine criteria (using the maximum daily effluent limit from the prior permit):
  - Acute: 93m
  - Chronic: 293m
- "Downstream" distance to meet mercury criteria:

[1] This is an acceptable option for sizing the acute mixing zone. See the *Technical Support Document for Water Quality-based Toxics Control* at Sections 2.2.2 and 4.3.2.

[2] Because Cormix is not "aware" of the boundary created by the shore, which is downwind of the discharge, model predictions at distances greater than about 200 meters may not be accurate. However, a predicted distance greater than 200 meters does mean that the water quality criterion will **not** be met at the point where the plume meets the shore, under the conditions specified in the model.

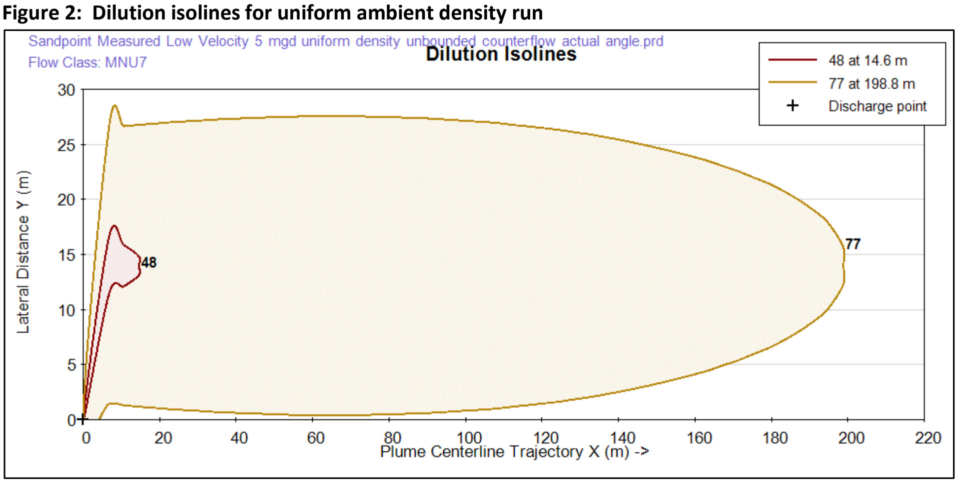
- Acute: 0 meters (discharge meets the acute criterion at the end of pipe)
- Chronic: 660m

- Cormix predicts that, when the City is discharging at the maximum projected effluent concentration of ammonia, the cold water aquatic life chronic ammonia plume extends 440 meters before it meets criteria yet the shoreline is only 281 meters from the end of the diffuser. The exact plume shape once it hits the shoreline cannot be predicted without more information. Ammonia has no human health criteria.

Commented [NB6]: When Mark set up the model back in2013, 281 meters (or 921 feet) was the distance from shore to the **far** end of the diffuser. The **near** end was only 757 feet, or 231 meters (the diffuser is about 50 meters long).

For the purposes of this modeling, I basically rounded down to 200. I'm fine with being more exact, but we should be using the distance from the shore to the **nearest** diffuser port (231 meters, not 281).

Figure 2: Dilution isolines for uniform ambient density run



~~1.2~~3.2 Stratified Ambient Density

- Chronic mixing zone: Dilution at 200 m downstream (shore~~, chronic MZ~~): 254:1
- Acute mixing zone: Dilution after 900 seconds (15 minutes) of plume travel ~~(acute MZ)~~: 220:1

Figure 3: Dilution isolines for stratified ambient density run